consistently left new species in synonymy unless their right to independent rank has been made clear. In general, the British Museum publications have been characterized by the assumption that a species is not valid until it is represented in the collections of the museum. There is room for many differences of opinion in regard to the relation of certain forms, and in regard to matters of nomenclature, but there can be no difference of opinion as to the great value of this work, and as to the accuracy of these fine plates, most of these being copies of the colored drawings of Mr. Garrett.

In the *Zoological Magazine* of Tokyo, Dr. Kishinouye has a paper on the Sparoid fishes of Japan. It is probably a valuable paper, but, being written almost entirely in Japanese, it becomes inaccessible to naturalists of the rest of the world, and it is hoped that this will not establish a precedent, at least unless a résumé in some modern language can accompany the descriptions of new species, and the new material which the writer is able to add.

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SOME RECENT BOOKS ON FOSSIL PLANTS

THE appearance within two years of three general works on paleobotany, is a sufficiently marked indication of the great interest which this phase of botany at the present time is exciting in England.[1] Much of the most important work which is now being published by the British botanists deals with fossil plants.

The English botanist is in some respects at a great disadvantage compared with his American colleagues. The comparatively meagre flora of the British Islands has already been exhaustively studied, and is a strong contrast to the extensive and varied flora of North America, which, except in the older parts of the country, still offers a rich field to the systematist and plant-geographer, as well as to students of morphology and physiology. This difference in the natural advantages of the two countries no doubt explains to some extent the greater interest in fossil plants shown by the English botanists. But unquestionably much more important is the availability of great collections of important fossils awaiting investigation; and the important

[1] Scott, D. H., "Studies in Fossil Botany," 2 vols., London, Adam and Charles Black, 1908–9. Seward, A. C., "Fossil Plants," Vol. II, Cambridge University Press, 1910. Stopes, Marie C., "Ancient Plants," Blackie & Son, London, 1910.

results already obtained by workers in this field offer great inducements to the young botanist. It must not be inferred that no interest is shown in the study of fossil plants by American workers, but paleobotany has not received the same attention here as in England.[2]

The many important contributions to the study of fossil plants by Scott and Seward are familiar to all students of paleobotany, and their treatises have the stamp of authority. Miss Stopes has published papers of much value, and her little volume presents in clear and fairly untechnical language some of the most important topics of the science. While the books of Professors Scott and Seward are designed primarily for botanical students, and are necessarily technical in their treatment, Miss Stopes's volume is intended mainly for the layman, and seems well suited to its purpose.

Professor Scott's two volumes deal almost entirely with the vascular plants, especially the Pteridophytes, which, as might be expected from the author's intimate knowledge of these forms, are handled in a thoroughly adequate fashion. The first volume treats of the Pteridophytes proper, while the second deals with the seed-bearing forms, including a very full and satisfactory treatment of those seed-bearing ferns, the "Pteridosperms" or "Cycadofilices," the investigations of which during the last ten or fifteen years have made such profound changes in our conceptions of the nature of the fern-like plants of the Paleozoic.

The Cycads and their fossil relations, the Benettiteæ, or Cycadeoideæ, are also treated at length, and the Cordaitales receive ample treatment; but the Conifers are passed over very briefly, and no account at all is given of the fossil Angiosperms, a group which is in woeful need of careful treatment by competent investigators.

Professor Seward's work is on a somewhat larger scale, and takes into account the whole vegetable kingdom. The work is, however, incomplete as yet. The present volume, the second of a proposed series of three, is devoted mainly to the Lycopods and ferns. The former volume comprised the Thallophytes and Bryophytes, together with the most of the Equisetineæ. The third and concluding volumes proposes to deal with the seed-bearing plants, including the Pteridosperms.

[2] In Coulter and Chamberlain's recent valuable treatise on the Gymnosperms, the fossil forms are treated at length, and this section of the book is one of its most valuable features. The important work of Wieland, Jeffry and other students of fossil plants in America must not be overlooked.

With these three books, at the same time reliable in their statements, and attractively written, English and American students can have no excuse for ignorance of the present status of paleobotany.

The attitude of botanists toward the study of fossil plants has undergone a marked change of late years. It is now no longer true that the students of fossil plants know little or nothing about living ones, and the great advancements of late years are largely due to the fact that recent students of fossil plants are thoroughly trained botanists. Moreover, as in other branches of botany, greatly improved methods have been developed, and the microscopic study of sections of petrified plant-tissues now make it possible in many cases to examine accurately the tissues of the fossil plants, and to compare them with the living forms supposed to be related to them. The perfection of some of these sections of fossil tissues is quite astonishing.

Of course it is the firmer tissues, like the epidermis and woody structures of the vascular plants which are most commonly preserved, and it is not strange that the paleobotanist should lay great stress upon the importance of the vascular skeleton which is so perfectly preserved. Students of living plants sometimes think that the great morphological importance attributed to the vascular system has been rather exaggerated, and there is no question that some of the far-reaching conclusions drawn from what to the layman seems very inadequate evidence, are not justified when they are taken in connection with the evidence furnished by a study of living forms. One can not accept without reserve many of the conclusions drawn from the study of fragmentary material, often very badly preserved. Nevertheless, no one can dispute that great advances have been made in our knowledge of the history of the development of the plant kingdom resulting from the discoveries made by students of fossil plants.

The problems which confront the student of fossil plants, and the difficulties which he encounters, are well set forth in the introductory chapter of Dr. Scott's book. The extremely fragmentary character of the record, and especially the great difference shown by different periods in the preservation of plant remains, are clearly set forth. The Carboniferous, as the students of fossil plants are aware, affords the richest fossil flora known, and it is especially with the Carboniferous flora that Dr. Scott concerns himself.

As it is among the Paleozoic Pteridophytes that we are to

look for the ancestors of the modern seed-bearing plants, the rich pteridophytic flora of the Carboniferous naturally takes first place, and it can be readily understood that an absorption in the study of these interesting fossils should perhaps overshadow the importance of other forms. One can not help feeling that if the search for remains of the Bryophytes in the Paleozoic rocks had been pursued with the same zeal as has been shown in the study of the vascular plants, something more than the extremely fragmentary evidences of their existence would be forthcoming.

Professor Seward, in his first volume published in 1898, has given an admirable account of the different methods of fossilization, and also the distribution of fossils. He points out in a very interesting and convincing way the evidences of the existence of the same factors at work at the present day as in times past. Perhaps the most striking fact brought out in the distribution of plant remains is the at first puzzling occurrence of fresh-water and land plants in deposits of evident marine origin. Professor Seward, however, shows that the great rivers of to-day, like the Amazon and the Mississippi, are carrying out to sea rafts of vegetation which may very well at some distant time be discovered as fossils covered by marine deposits, to puzzle the geologists of that future epoch.

The history of the fossil Thallophytes remains very much as it was at the time Professor Seward's first volume was published, a rather significant comment on the neglect of these important plants when compared with the great advances made in our knowledge of the fossil Pteridophytes and Gymnosperms during the past decade.

As most of the Thallophytes, especially the algæ, are extremely delicate and perishable organisms, the rarity of recognizable fossil remains is not to be wondered at. Where there is a calcareous incrustation, as in the coralline algæ and many Siphoneæ, very perfect fossils have been preserved. The latter group is especially well represented in a fossil state and has received considerable attention from the paleobotanists. Some of these Siphoneæ can be traced back to the Silurian, and the order is evidently a very old one. A study of these algæ shows that, as at the present day, they played a by no means unimportant rôle as reef-builders.

Among the most characteristic of fossil plants are the Diatoms. While these have left enormous deposits of their flinty shells in the Cretaceous and later rocks, they are practically unknown in

the earlier formations. It is highly probable that in spite of their simple structure the Diatoms are really comparatively recent types. Their enormous numbers and practically universal distribution at the present time, indicate that they are admirably adapted to existing conditions. They particularly abound in the Arctic and Antarctic seas.

While the Fungi are rarely preserved in a very satisfactory condition, there is abundant evidence of their presence in the Paleozoic rocks.

The geological history of the Bryophytes is in a very unsatisfactory condition. Of the liverworts only a few impressions are recorded, and these, according to Seward, are all from Mesozoic or Tertiary formations, and so closely resemble the living species that they throw no light upon the early history of the group. Very few fossil remains which can with certainty be referred to the true mosses are known, but the possibility of confusing the remains of mosses with small Lycopods or even fragments of coniferous branches has to be taken into account.

It has been suggested that the very small number of unmistakable Bryophytes which has been recorded in a fossil state might be explained in the same way as we have suggested for the absence from the Paleozoic rocks of Diatoms; but the cases are hardly parallel since the Bryophytes, particularly the liverworts, give every evidence of being old and generalized types, and do not appear to be particularly well adapted to modern conditions, except as these duplicate what we may assume to have been the conditions during the Carboniferous. It is only in the extremely moist, even climate of the mountain tropics, where the other Paleozoic type, the Pteridophytes reaches its greatest luxuriance, that the liverworts form a conspicuous feature of the flora. Moreover, the liverworts are far less plastic, the number of species, even of wide-spread genera (except in the leafy forms) being usually very small. Both their distribution and their structures point unmistakably to their being a primitive group.

The absence of liverworts from the early geological formations can most readily be explained on the score of their great delicacy, which would prevent their being preserved in a recognizable form. Even were we to admit that the liverworts are modern types, we should still have to explain why their progenitors, and the presumably similar progenitors of the ferns, have not been found in a fossil condition. A parallel case is found in the Cretaceous and Tertiary formations, where the great deposits

of perfectly preserved plant remains are almost entirely referable to trees and shrubs, while the host of herbaceous plants, like the grasses and delicate herbs forming the carpet of the forests, are conspicuous by their absence. If magnolias and maples were abundantly developed in the Tertiary forest, we may be sure that there were also buttercups and violets, although we have no impressions of their leaves and flowers. The same explanation for the extreme scarcity of impressions of herbaceous plants in the Cretaceous and Tertiary formations may be applied to the much more delicate hepatic flora of the Paleozoic.

In the light of comparative morphology, we think most botanists will agree that it is in the highest degree probable that the simpler liverworts, like *Aneura* and *Pellia,* are extremely ancient types, which, like the majority of the algæ, owing to their very delicate and perishable tissues, simply have failed to leave recognizable fossil traces. The only structures of the liverworts which one might hope to recognize in a fossil state are the elaters. It may be that a careful examination of sections of the masses of petrified vegetation resulting from the débris of the Carboniferous forests, may show liverwort elaters, but as yet no such discovery has been recorded. It is also by no means impossible that among the numerous beautifully preserved leaf impressions of the Paleozoic ferns, some might under specially favorable conditions show traces of epiphyllous liverworts, such as are common on fern leaves at the present day in wet tropical forests.

It is the Pteridophytes and their allies among the simpler seed-bearing plants that have largely monopolized the attention of the paleobotanists during the past decade or two. The results of these investigations have been to quite readjust the views long held as to the real nature of many of the Paleozoic fossils. These changes have been mainly among the fern-types, although among the Equisetineæ and Lycopods there have also been important discoveries.

The history of the fossil Equisetineæ need not be dwelt upon here. It is sufficiently well known that this class, at the present day reduced to some twenty-five species belonging to the single genus *Equisetum,* was an important factor in the rich Paleozoic flora. Professor Scott, in the first volume of his studies, gives an excellent account of the present status of our knowledge of this class.

The Lycopods, also a comparatively degenerate group at the present day, showed much greater range of structure and size than at present. The most important discovery of late years

among the fossil Lycopods is the fact that some of the great fossil club-mosses, *e. g., Lepidocarpon,* bore unmistakable seeds. This adds one more instance of the independent origin of seeds in quite unrelated orders of Pteridophytes.

It is among the ferns, however, that the interest of the paleobotanist has been especially centered, both in England and on the continent. The abundance and perfection of the fern-like fossils of the Paleozoic, especially those of the Carboniferous, are sufficiently familiar, but a very large percentage of them are merely impressions of sterile fronds. Numerous investigations of these supposed fern-leaves have proved beyond question that they are not ferns in the strict sense of the word, but are the sterile leaves of fern-like plants which bore true seeds. It has become apparent that these seed-bearing ferns, "Pteridosperms," formed a very important feature of the Carboniferous flora, perhaps outnumbering the true ferns. Indeed, some enthusiastic students of these interesting plants have gone so far as to doubt whether true ferns existed at all at this period!—a conclusion with which it is needless to say few botanists would be inclined to agree. True ferns must have preceded Pteridosperms, and it is hardly likely that none of them should have left fossil remains, not to mention the fact that many of the fossil fronds bear sporangia of whose true fern nature there can be no reasonable doubt.

Of the living ferns, the Marattiaceæ are best represented among the Paleozoic fossils, and their primitive nature is also shown by a study of their structure and development. Most of the Pteridosperms were probably derived from ferns of this type, and it is in many cases apparently not possible to decide whether certain leaves bearing sporangia of the Marattiaceous type are true ferns, or whether they represent the microsporangia of some Pteridosperms. It does not follow, however, as some students of Pteridosperms have argued, that because the sporangia of one doubtful Marattiaceous fern have been shown to belong to a Pteridosperm, that therefore we must suspect all of the sporangia of the Marattiaceous type.

The geological history of the other living family of the eusporangiate ferns, the Ophioglossaceæ, is extremely unsatisfactory. The great rarity of recognizable fossils belonging to this family may perhaps be explained by the perishable nature of their leaves. The soft leaves of *Ophioglossum* and *Botrychium* and the absence of indurated cells from the sporangium would make these plants very poorly fitted for preservation in a fossil state.

It is, however, by no means impossible that some of the earliest known ferns, the Botryopterideæ, may have been related to the Ophioglossaceæ. Both the form of the leaves, and the sporangia which were borne on special leaf segments, are suggestive of the Ophioglossaceæ, and there are also certain anatomical resemblances.

One of the earliest fern-like fossils is the Devonian genus *Archæopteris*. This fossil in the venation of the leaves suggests the simpler types of *Botrychium,* and the sporangia are borne on special leaf segments, which, however, it must be said more nearly resemble *Osmunda* than they do *Botrychium*. Professor Seward is inclined to believe that the sporangia of *Archæopteris* are really pollen-sacs of a Pteridosperm, stating that they are much larger than the sporangia of any known fern, being two or three mm. in length. It is evident that Professor Seward overlooked the Ophioglossaceæ in making this comparison, and it is with these that the comparison really should be made. The sporangia of *Archæopteris* are described as pear-shaped sacs, two to three mm. in length. These are nearly equalled in size by some species of *Botrychium,* such as *B. Lunaria* and *B. silaifolium,* in which the globular sporangia may be 1.5 mm. in diameter, while the sporangia of the large species of *Ophioglossum* very much exceed in size these figures. In *O. pendulum* the sporangia are probably larger than those of any other living Pteridophyte, and may reach a diameter of four millimeters. It is clear then that the mere question of size is not a valid argument for considering *Archæopteris* a Pteridosperm rather than a homosporous fern.

The evidence of the fossil record entirely bears out the conclusions based upon a study of the living ferns that the condition in which the sporophyll, or parts of it, are entirely devoted to spore-production, as in *Ophioglossum* and *Osmunda,* is a more primitive condition than that in which the sporangia are produced upon the backs of unmodified leaves.

There is abundant evidence from a study of existing Archegoniates that the sporophyte of the fern is the result of the elaboration of the sporogonium of some bryophytic ancestor. This being the case, it necessarily follows that the sporophylls are older phylogenetically than the sterile leaves, and are not secondary modifications of the latter. It is to be hoped that students of the Botryopterideæ and other archaic fern types will make a thorough comparison of these with the existing Ophioglossaceæ, in the light of the most recent developmental studies

on the latter. Whether or not we admit the relationship of *Ophioglossum* with these ancient ferns, there is no question that both in regard to the early history of the sporophyte and in the structures of the adult sporophyte, *Ophioglossum* most nearly represents among living ferns what we may fairly assume to have been the primitive type from which the higher ferns have sprung.

In view of the abundant evidence of the primitive nature shown by the living Ophioglossaceæ, we can not believe that these plants did not exist in the earlier geological epochs; and the failure to record them is due either to the complete disorganization of their delicate tissues, or to a failure by investigators to recognize the ferns allied to them which may have been found in a fossil state.

Dr. Scott in his second volume gives an excellent account of the Cordaitales and the Cycads, but it is to be regretted that his treatment of the Conifers is so brief. He explains this by stating that the present knowledge of the fossil Conifers is not sufficiently exact to make a satisfactory general treatment feasible. It is to be hoped that in the concluding part of Professor Seward's treatise they will receive adequate attention.

The Cordaitales, the earliest known seed plants and completely extinct at the present time, are remarkable for the perfection with which their floral structures, as well as their vegetative tissues, have been preserved. They evidently represent a more or less synthetic type with apparent connections with several of the other great groups, but their exact place in the system is still not quite satisfactorily settled.

The advance in our knowledge of the "Cycadophytes"—the Cycads and their relations—during the past ten years has been very great, largely due to the labors of an American paleobotanist, Dr. Wieland.[3] His remarkable studies on the wonderfully preserved Mesozoic Cycads of the Black Hills Region of South Dakota and Wyoming, form one of the most notable contributions to fossil botany that have been made for many years. These Mesozoic Cycads are separated from the recent type of Cycads as a distinct family, the Benettiteæ or Cycadeoideæ. It is the floral structures of these plants that have attracted the greatest attention, as they show a curious similarity in their general structure to such a flower as a magnolia, although they are gymnosperms. This resemblance is so striking that some stu-

[3] Wieland, G. R., "American Fossil Cycads," Carnegie Institution of Washington, Publication No. 34, 1906.

dents have even gone so far as to assume an origin for the lower Angiosperms from some similar type. Much more evidence, however, is necessary before so startling a theory can be accepted.

Professor Scott gives only a brief summary of the fossil history of the Conifers. The order can be traced back to the Permian and it is possible that some types are still older. The oldest recognizable Conifers were apparently allied to the modern Araucarias, and it may be noted in this connection that Seward has expressed the opinion that the Araucariaceæ show sufficient similarity to the Lycopods to warrant the hypothesis that they may have descended from some of the great seed-bearing Lycopods of the Carboniferous. True Araucariaceæ occur from the Triassic, and probably existed in still older formations.

The Taxodineæ to which our bald cypress and Sequoia belong, may go back to the Permian, but there seems to be some doubt of the real relationships of the earliest fossils placed in this family. The Abietineæ, *i. e.*, the pines and firs, do not occur before the later Jurassic and early Cretaceous formations, and the true cypresses seem to be of about similar age. The Taxaceæ, the Yew family, is apparently the most recent of the Conifers, not being found below the Cretaceous.

The geological history of the Angiosperms is very incomplete, and they have received very much less attention than the Pteridophytes and Gymnosperms which have so largely monopolized the attention of the paleobotanist. It would seem as if a critical investigation of the abundant Cretaceous and Tertiary remains of the Angiosperms, comparable to the many complete studies on the Paleozoic and Mesozoic Pteridophytes and Gymnosperms, should yield results which would throw some light upon the origin of the predominant plant-type of the present day.

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